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MODEL 2860

DATA AMPLIFIER

DANA™

Dana Laboratories Incorporated
Irvine, California 92664

Telephone (714) 833-1234
Teletype 910-595-1136

INSTRUCTION MANUAL

980242

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SECTION 1

GENERAL DESCRIPTION

1.1 INTRODUCTION

The Dana Model 2860 is a passive-guard differential amplifier with low noise at gains up to 2500, high level of common mode rejection, and fast settling time. Full-scale output is ±10 volts and ±100 milliamperes.

The Model 2860 features the advantages of direct-coupled amplifiers (linearity, low zero drift, low noise) with the 300-volt common mode operating capability that is characteristic of modulation-coupled amplifiers.

A front-panel bandwidth control allows the output to be set at any one of five selected bandwidths: 10Hz, 100Hz, 1kHz, 10kHz and wideband. The minimum -3dB frequency in the wideband position is 50kHz.

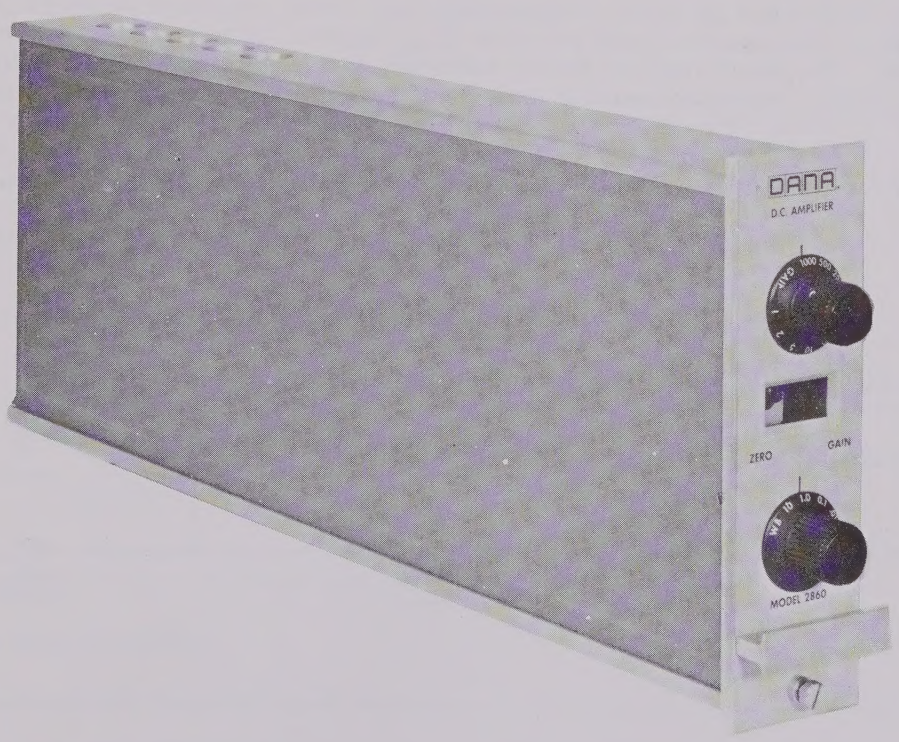


Figure 1.1 - Model 2860 Data Amplifier

The input, output, and power supply of the Model 2860 contain RF interference suppression from external RF noise. The Model 2860 provides almost complete isolation between the input leads and output common. If desired, the Model 2860 may also be used as a single ended unit, inverting or non-inverting, in applications in which either the source or the load is isolated from the ground. The common-mode rejection is 120dB, dc to 60 Hz.

Circuits within the amplifier prevent damage from short circuits and from fault voltages up to 30 volts normal mode.

System noise contributed by the amplifier circuitry is exceptionally low. The noise referred to the input (RTI) at a gain of 1000 is less than 5 microvolts rms in full bandwidth and less than 1 microvolt, peak-to-peak, in a 10Hz bandwidth.

1.2 OPERATIONAL DESCRIPTION

A block diagram of the Model 2860 is shown in Figure 1.2. The Preamplifier amplifies the normal mode signal. The amplified signal is modulated and applied to the isolation transformer, demodulated, and further amplified by the Output Amplifier. The common mode potential (E_{CM}) appears between the transformer shields. The input guard or shield surrounds the Preamplifier as well as the input leads. When the guard is referenced to the common mode potential, the

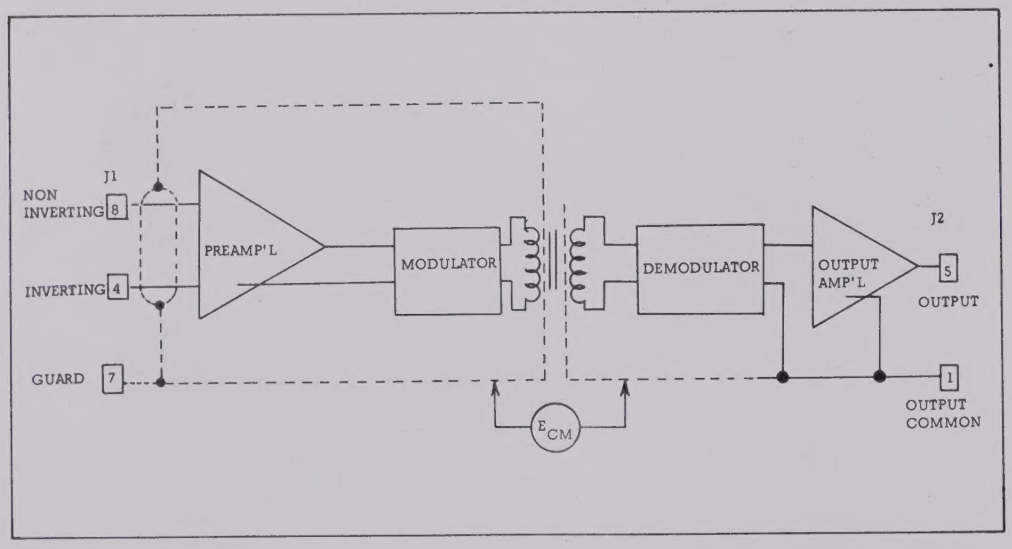


Figure 1.2 - Block Diagram, Model 2860

common mode potential is isolated from the preamplifier achieving the high common mode rejection required for data amplifiers. The passive guard or passive shield can reject a greater magnitude of common-mode voltage than the active-guard amplifiers and is characterized by constant common mode rejection - not affected by gain setting.

The Output Amplifier contains an operational amplifier and an active-admittance amplifier. The output voltage of the Output Amplifier is ±10 volts across a 100 ohm load.

Capacitors in the active-admittance filter are switched with each position of the BANDWIDTH switch to set the upper limit of each bandwidth.

Precision resistors in the Preamplifier are switched with each position of the GAIN switch to set the gain of the amplifier. A vernier extends each range equal to 2-1/2 times the nominal gain setting.

A more detailed description of the circuits of the Model 2860 is given in Section 4 - Circuit Description.

1.3 GAIN OPTIONS

Two gain options are available and must be specified when ordering the amplifier. They are designated as gain options V4 and V5. The Models 2860 V4 and 2860 V5 are especially suited in applications where low-level, millivolt signals are to be amplified to voltage levels for accurate recording or measuring and in applications where common mode potentials are greater than 10 volts dc or peak ac.

1.3.1 Option V4

The V4 option provides gain steps of 1, 2, 5, 10, 20, 50, 100, 200, 500, and 1000. A vernier multiplier extends each gain by a factor of 2.5:1. Gain accuracy of the V4 option is ±0.1%.

1.3.2 Option V5

The V5 option provides the same gain steps and vernier multiplier as the V4 option. However, the gain accuracy of the V5 option is ±0.01%.

1.4 SPECIFICATIONS

Specifications are listed in Table 1.1.

1.5 AMPLIFIER ENCLOSURES

The 2808 Enclosure accommodates eight amplifiers. The enclosure is 7 inches in height with a depth of 22 inches and a width, including flanges, of 19 inches.

Table 1.1 - Specifications

DANA MODEL 2860 SPECIFICATIONS	**All specifications apply for 0 to 1000 ohm source, in any unbalance.**
Gain	
Range	1 to 2500 with 2.5:1 vernier
Steps	1, 2, 5, 10, 20, 50, 100, 200, 500, 1000
Accuracy	±0.01% V5 option; ±0.1% V4 option
Resolution	±0.01% (±0.03% worst case)
Stability (at gain setting and constant temperature)	±0.01% (200 hrs)
Temperature coefficient	±0.005%/°C
Output (no damage for sustained short circuit)	
Full scale voltage	±10 V
Voltage overrange, nominal	20%
Full scale load current	±100 mA
Maximum short circuit current	±150 mA (adjustable to ±60 mA)
Impedance	0.1 ohm in series with 30μH
Capacitive load, without instability	Infinite
Capability	Full scale voltage and current to 50 kHz
Frequency Response (at full output)	
Wideband	
dc to 100 Hz	±0.01%
Minimum 3 dB frequency	50 kHz
Variband	
Filter characteristics	3 pole Bessel
Switch selectable cutoff frequencies (f_{co}) of	10 Hz, 100 Hz, 1 kHz, 10 kHz, wideband
Attenuation at selected f_{co}	−3 dB ±1 dB
Attenuation above selected f_{co}	−60 dB/decade
Linearity	
dc to 2 kHz	±0.01%
Common Mode	
Rejection ratio at dc	140 dB
Rejection ratio dc to 60 Hz	120 dB
Operating voltage dc to 60 Hz	300 V dc or peak ac
Fault voltage dc to 60 Hz without damage	300 V dc or peak ac
Noise	
Full bandwidth	3μV rms RTI + 2 mV rms RTO
10 kHz bandwidth	1μV rms RTI + 1 mV rms RTO
10 Hz bandwidth	1 mV peak to peak RTO, for any gain
Input Impedance	
Normal mode	10,000 MΩ, parallel with 0.001 μF
Zero Stability	
At constant temperature (after 30 minute warm-up)	±0.02% (200 hrs)
Temperature coefficient	(±0.002% RTO ±1 μV RTI)/°C and ±0.5 nA RTI/°C
Step Function Response	
Settles to final value ±0.01% of full scale in	$175\ \mu\text{sec} + \frac{1.6\ \text{sec}}{f_{co}}$
Overload Recovery	
Settles to final value ±0.01% of full scale for 5 times full scale input for gains of 5 to 2500 or 10 V for gains of 1 to 5 in	$400\ \mu\text{sec} + \frac{1.6\ \text{sec}}{f_{co}}$
No damage for 30 V dc or peak ac input on any gain	
Temperature Range	
Operating	0°C to +50°C
Storage	−20°C to +75°C
Power Requirement	
Domestic	105 to 125 V rms, 50 to 400 Hz, 10 watts
Export Option 1	200 to 240 V rms, 50 to 400 Hz, 10 watts
Export Option 2	215 to 265 V rms, 50 to 400 Hz, 10 watts
Export Option 3	90 to 110 V rms, 50 to 400 Hz, 10 watts
Enclosure	
Model	2808-1 or 2808-2
Capacity	8 amplifiers fit in a standard 7 inch by 19 inch panel space
Bench Operation	
Model	2801 single unit adapter

The basic model is modified by a "dash" number which specifies the type of wiring.

The 2808 Enclosure accommodates all of the Dana Series 2800 Amplifiers. The amplifiers are interchangeable in the enclosure without alteration of the input and output cables.

The -1 Enclosure contains connectors to accommodate system wiring. Fusing and AC wiring are factory wired. An outline drawing (452402) is included in Section 6, "Drawings and Parts Lists".

The -2 Enclosure is fully wired. The inputs and outputs are accessible through connectors mounted on the rear panel. An outline drawing (452403) is included in Section 6, "Drawings and Parts Lists".

Wiring instructions for each type enclosure are included in Section 2, "Installation".

1.6 AMPLIFIER ACCESSORIES

An Adapter Set Model 2801 (Dana part number 402468) and an Amplifier Support Bracket (Dana part number 452411) are used when the amplifier is operated on the bench. The Adapter Set (item 1 in Figure 1.3) contains input leads, output leads, and the power cord. The Amplifier Support Bracket (item 2 in Figure 1.3) mounts to the amplifier to support the amplifier in an upright position.

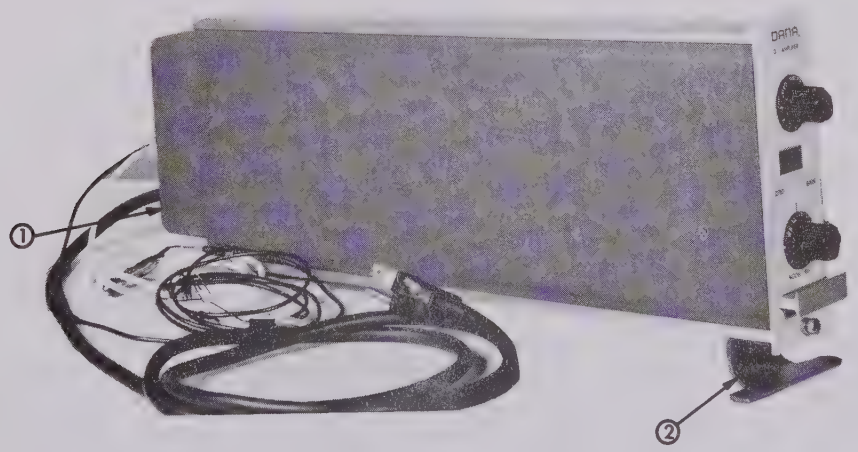


Figure 1.3 - Amplifier Accessories

SECTION 2

INSTALLATION AND INITIAL CHECKOUT

2.1 UNPACKING AND INSPECTION

The Dana Amplifier is shipped in a special reusable shipping package, designed to protect the instrument from excessive shock and vibration. Examine the package for signs of external damage before removing the unit. If external damage is present, notify the carrier before proceeding. Next, examine the outside of the amplifier for any evidence of damage due to excessive shock, vibration, water leakage, etc.

If the unit appears in perfect condition, proceed with the installation. However, if there is any apparent damage, communicate with the carrier for instructions.

2.2 POWER REQUIREMENTS

Dana Amplifiers, manufactured for domestic use, operate on 115 volts (±10 volts), 50 to 400 Hz. Units manufactured for export operate on 210 to 250 volts, 50 to 400 Hz. Power required is eight watts.

> NOTE
>
> If the Amplifier has been stored for a prolonged period (5 or 6 months) without use, it is recommended that it be operated with a variable transformer, such as a Variac, at one-half line voltage for about two hours before gradually applying full power. This is done to "reform" the electrolytic capacitors in the amplifier and reduce the chance of capacitor failure.

2.3 INPUT - OUTPUT CONNECTIONS

Input and output connections to the amplifier are through an eight pin connector (J1) at the rear of the amplifier (see Figure 2.1). External connections are brought in through a mating connector. When the Dana enclosures are used, the mating connector for each amplifier is mounted on the inside back panel of the enclosure; each amplifier plugs into its corresponding connectors. When amplifiers are used singly, a single unit adapter set is normally used. The adapter set (Dana part number 402468) includes the mating connector, power cord, and clip leads for input and output signal connections.

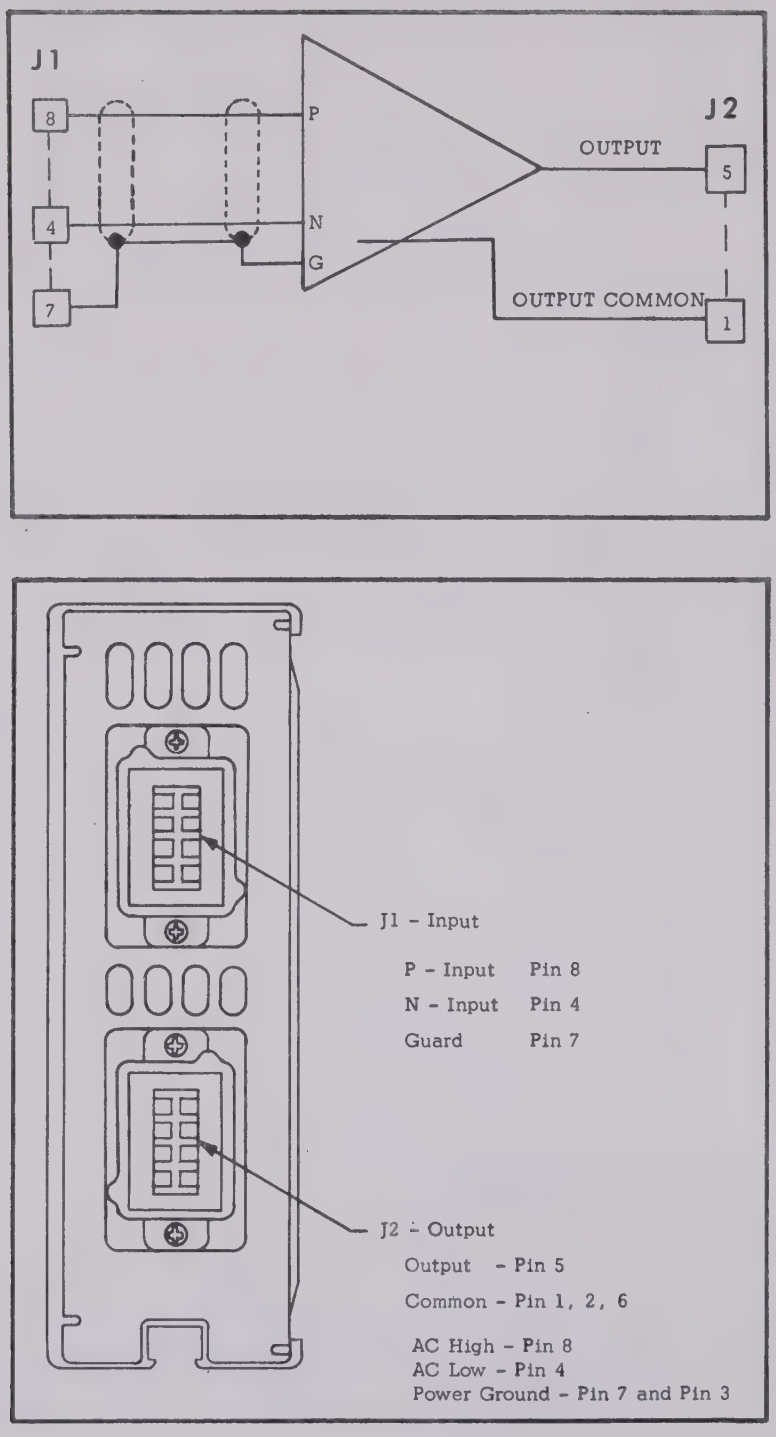


Figure 2.1 - Input/Output Connections

When the 2808-1 Enclosure is used, external connections are made directly to the solder side of the enclosure mounted connector for each amplifier. Access to connectors is gained by removing four screws holding the rear panel and allowing the top of the rear panel to drop away from the enclosure. External leads are routed through the grommet holes and soldered to the connectors.

In the 2808-2 Enclosure, conventional cable connectors are mounted on the rear panel. Connections are made by wiring to the mating connector. All pin connections are identified in Figure 2.2.

2.3.2 Power

When the Amplifier is to be operated within the 2808-1 or 2808-2 Enclosure, power is prewired and a three-wire line cord is supplied. When using the cord set, power and input/output connections are prewired. The power cord is connected to P2 of the cord set.

The ground wire of the power cord connects to the internal power supply shield of the amplifiers.

2.3.3 Input/Output Signals

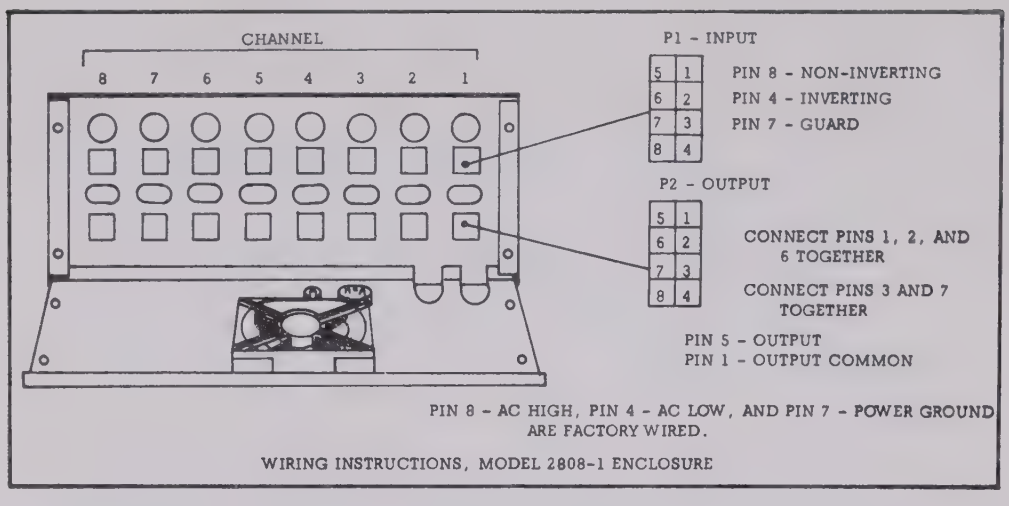
Input wiring configurations are extremely important in minimizing common mode voltages. The guard lead should be connected as close as possible to the signal source. Input and output connections are shown in Figure 2.2.

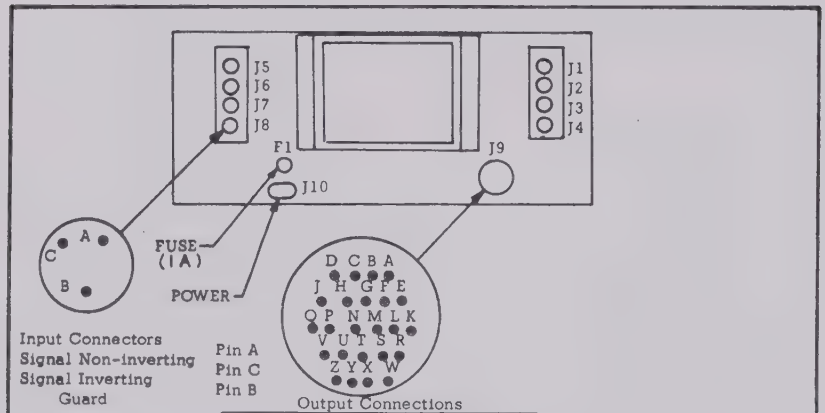
For permanent installations, low thermal solder (70% cadmium, 30% tin) should be used for all input connections to reduce thermalcouple errors. For temporary or test setups, screw terminals or clips having low resistance may be used, taking suitable care to minimize thermal emf's (a few microvolts can be significant on high gain ranges.

Since P and N inputs to the amplifier are symmetrical (approximately equal impedance to output common), either lead may be connected to either side of the signal source. For phasing purposes, if P is positive with respect to N, the output is positive with respect to output common.

Input leads should be two-conductor in an insulated shielded cable (Belden #8451-500, or equivalent). The shield must be soldered to the guard pin connection (pin 7 of J1 when a -1 Enclosure is used; pin B of the signal input connector for a -2 Enclosure). The unshielded portion of the leads must be kept as short as possible.

A single-conductor shielded cable is recommended for output leads. If two-conductor is used, connect one lead and shield together at either end or both ends. Solder the shield to Output Common (pin 1 of J2 for -1 enclosures; see Figure 2.1 for -2 enclosures). The enclosure chassis is connected to ground by the power cable. The lead from the output common terminal of the amplifier should be connected directly to the input common or ground of the output device.


CHANNEL
8 7 6 5 4 3 2 1
P1 - INPUT
5 1
6 2
7 3
8 4
PIN 8 - NON-INVERTING
PIN 4 - INVERTING
PIN 7 - GUARD
P2 - OUTPUT
5 1
6 2
7 3
8 4
CONNECT PINS 1, 2, AND 6 TOGETHER
CONNECT PINS 3 AND 7 TOGETHER
PIN 5 - OUTPUT
PIN 1 - OUTPUT COMMON
PIN 8 - AC HIGH, PIN 4 - AC LOW, AND PIN 7 - POWER GROUND ARE FACTORY WIRED.
WIRING INSTRUCTIONS, MODEL 2808-1 ENCLOSURE



CHANNEL	OUTPUT	OUTPUT COMMON
1	A	B
2	E	F
3	K	L
4	R	S
5	W	X
6	D	C
7	J	H
8	Q	P

CHASSIS GROUND PIN Z

NOTES: (1) Use shielded two conductor twisted pair cable for input leads. Shield is soldered to Guard Pin Connection.

(2) Single conductor shielded wire is recommended for output leads. Solder shield to output common pin.

(3) Viewing enclosure from the front, amplifiers are numbered from left to right.

	Mating Connector & Clamps	Dana Part Number
INPUT	3106 A-10 SL-3S A105-A115	601561
(8 sets required)	3057-4A-A105 w/Bush	601474
OUTPUT	3106 A-24-28P-639	601563
(1 set required)	3057-16A-639 w/Bush	601564
AC POWER	Belden Power Cord #17256	600127
(1 set required)		

Wiring Instructions, Model 2808-2 Enclosure

Figure 2.2 - Enclosure Wiring

2.4 INITIAL CHECKOUT PROCEDURES

The amplifier is accurately adjusted and carefully inspected at the factory. The following tests check basic characteristics of the amplifier to verify proper operation upon delivery. The type of damage that can be expected in shipment tends to produce gross malfunctions rather than minor changes in sensitive characteristics. More complete and precise tests and calibration procedures are included in Section 5, "Calibration".

Only three items of test equipment are required to perform initial checkout of the amplifier:

- Audio Oscillator
- Voltage Divider/Attenuator
- Oscilloscope

Standard laboratory-type instruments from any manufacturer may be used.

2.4.1 Gain Checkout

1. Connect the common or ground terminals of each item of test equipment to a single point and to the amplifier output common (pin 1 of J2). Connect this point to ground. Make all measurements relative to this point (see Figure 2.3).

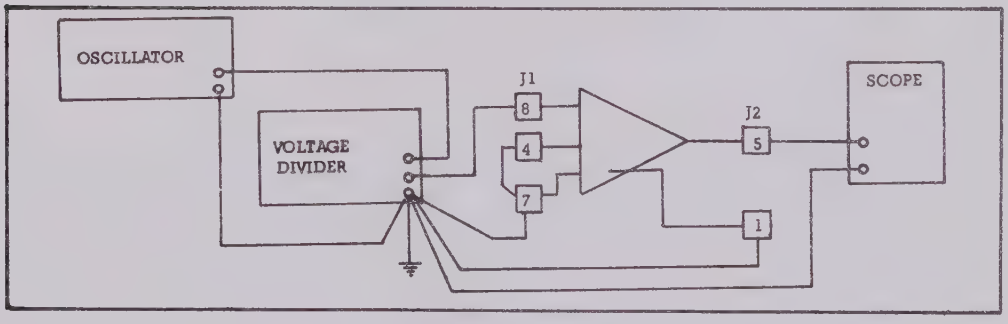


Figure 2.3 - Gain Test Setup

2. Set voltage divider to minimum output — zero, if possible.

3. Apply power to amplifier. Observe amplifier output on oscilloscope. It should be within a few millivolts of ground and change only very slightly as the amplifier GAIN switch is rotated.

4. Set the VERNIER gain adjustment fully counterclockwise.

5. Set the GAIN selector switch at the highest gain position.

6. Remove scope lead from amplifier output and connect scope to the oscillator output. Adjust oscillator for 20 volts, peak-to-peak, at 100 Hz.

7. Set voltage divider to the reciprocal of the maximum gain setting, 1/K. (For example, at maximum gain of 1000, set divider to 0.001.)

8. Return the scope to the amplifier output, pin 5 of J2. The scope should now indicate approximately the same value, 20 volts peak-to-peak, observed at the oscillator output. (The term "approximately" is used because of the limited capability of an oscilloscope to compare two magnitudes accurately.)

9. Verify that there is no obvious noise or other unexplained distortions on the oscilloscope trace.

2.4.2 Frequency Response Checkout

1. Use test setup exactly as connected for Gain checkout. Set amplifier GAIN control at maximum; vernier adjustment to minimum. Connect scope to oscillator output; set oscillator frequency to 50 kHz. Set the BANDWIDTH switch to the WB(wideband) position.

2. Set oscillator output at 20 volts, peak-to-peak (on scope).

3. Remove scope lead from oscillator and connect to amplifier output pin 5 of J2. Adjust voltage divider for amplifier output amplitude equal to that observed in step 2.

4. Compare voltage divider setting with zero — or minimum output position. The difference should be no less than 3dB, or approximately 30%.

2.4.3 Common Mode Rejection

1. Short the amplifier input leads and the input guard lead (pins 8, 4, and 7 of J1). Connect these leads to the high side of a signal generator.

2. Connect oscilloscope to amplifier output (pin 5 of J2).

3. Set oscillator output to 20 volts, peak-to-peak, at 60 Hz.

4. Set amplifier GAIN switch to 1000.

5. Observe amplifier output on scope. The output due to common mode is normally not detectable above the wideband noise of the amplifier. Common mode rejection can be calculated as follows:

$$CMR = \frac{20 \text{ Volts (P-P)} \times K}{\text{Output Voltage (P-P)}}$$

SECTION 3

OPERATION

3.1 CONTROLS

3.1.1 Gain Selector Switch

The GAIN switch is rotated to select the desired gain of the amplifier. One of ten gain positions may be selected. The selected gain is inscribed on the knob of the gain selector switch.

3.1.2 Bandwidth Switch

The BANDWIDTH switch allows selection of the amplifier bandwidth. It is calibrated in kilohertz and has the following positions:

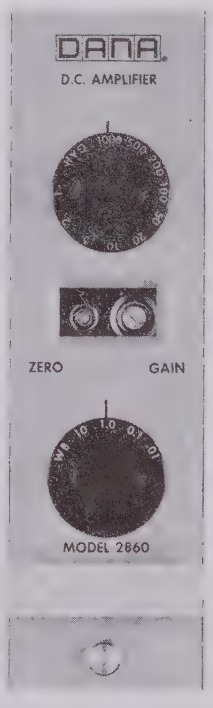
Switch Position	Bandwidth
0.01	DC to 10Hz
0.1	DC to 100Hz
1.0	DC to 1000Hz
10.0	DC to 10kHz
Wideband (WB)	Full Bandwidth

3.2 OPERATIONAL ADJUSTMENTS

3.2.1 ZERO Adjustment

ZERO is a screwdriver adjustment on the front panel of the amplifier. It is used to set the output voltage to zero volts with no input. It is adjusted in the following manner:

1. Apply power to the amplifier and any adjoining heat-producing equipment and allow amplifier to stabilize (approximately 30 minutes).
2. Set GAIN selector switch to lowest gain position.
3. Return the input P(J1-8) and N(J1-4) leads to output common (J2-1).
4. Connect voltmeter or scope to amplifier output (J2-5) and common (J2-1).



Model 2860

5. Adjust ZERO for zero amplifier output. Counterclockwise rotation corrects for a positive output; clockwise rotation corrects for a negative output.

3.2.2 GAIN Adjustment

This is a screwdriver adjustment which serves as a vernier adjustment of gain selected by the GAIN selector switch. The adjustment varies each gain position by a factor of 2.5:1 — providing continuous gain selection throughout all available ranges.

3.3 OPERATING PROCEDURES

After installation of the amplifier as described in Section 2, operation consists simply of selecting the appropriate gain. The amplifier is ready for use immediately with zero stability achieved within 30 minutes.

SECTION 4

CIRCUIT DESCRIPTION

4.1 INTRODUCTION

A block diagram of the Model 2860 amplifier is shown in Figure 4.1. The forward loop consists of the preamplifier, isolator, and output amplifier. The preamplifier amplifies the potential difference between the two inputs e_1, e_2. The output of the amplifier is proportional to the difference of the amplitudes. These signals are referred to as "normal mode signal" (also referred to as "difference" or differential signals). The potentials common to both inputs are referred to as "common mode potentials" and are physically isolated from the preamplifier by a mechanical enclosure.

The normal mode signals are defined as

$$\text{Normal Mode Signal} = e_2 - e_1$$

$$\text{Output } (E_o) = (e_2 - e_1)\ (\text{Gain})$$

In single ended operation, a signal is applied to e_2 while e_1 is common; therefore, the output is proportional to the amplitude of the one signal applied.

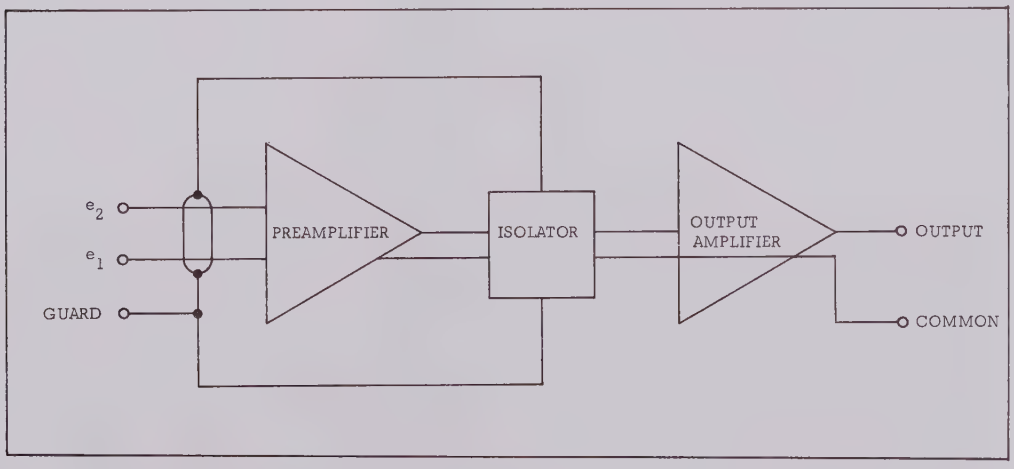


Figure 4.1 - Block Diagram, Model 2860 Amplifier

4.2 PREAMPLIFIER

The Preamplifier is shown in Figure 4.2. The normal mode signals are converted into current and applied to the isolator. The gain resistor (R_G) scales the input voltage such that the full scale current (i) to the isolator is 1 milliampere for all possible full scale input signals (10 millivolts to 10 volts). The required resistor R_G is switched into the circuit by the GAIN switch on the front panel. Values of R_G range from 10 ohms to 10,000 ohms according to the relation

$$R_G = \frac{e_2 - e_1}{1 \text{ milliampere}}$$

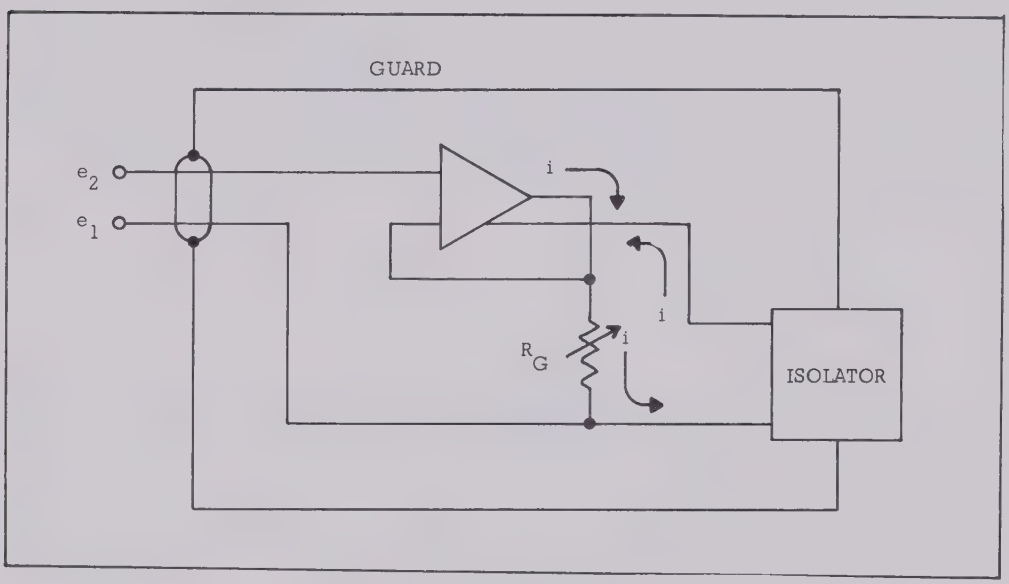


Figure 4.2 - Preamplifier

4.3 ISOLATOR

The Isolator contains a transformer, a modulator, and a demodulator as shown in Figure 4.3. The current enters the primary winding of the transformer from the preamplifier, is modulated, and coupled to the secondary winding of the transformer where it is demodulated in the demodulator section of the isolator. The modulator and demodulator are synchronized from the same source for the proper phasing of the signal. An astable multivibrator provides the switching source to the modulator switches and the demodulator switches as shown in Figure 4.4.

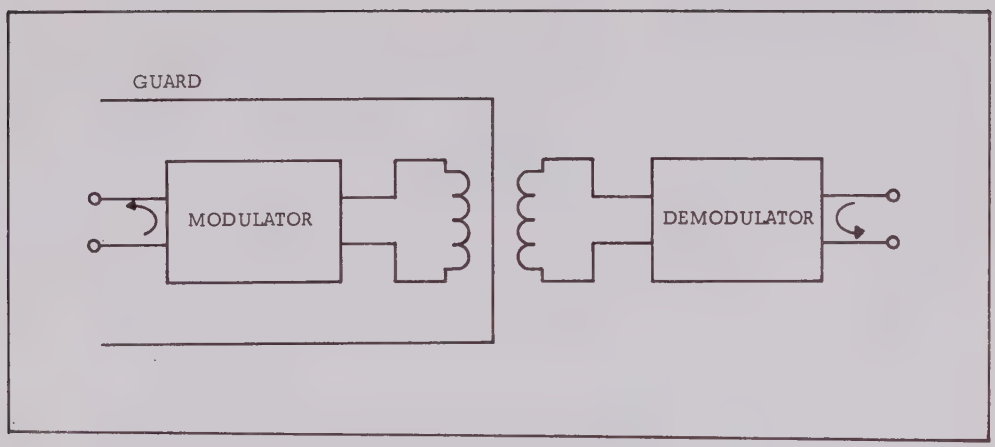


Figure 4.3 - Isolator

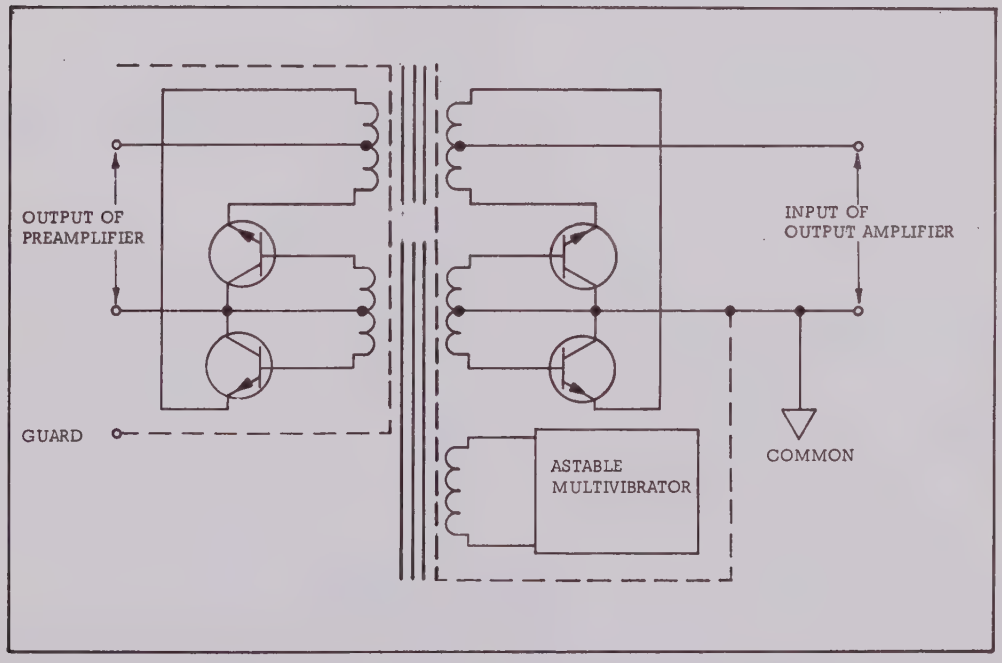


Figure 4.4 - Modulator and Demodulator

4.4 OUTPUT AMPLIFIER

The Output Amplifier (Figure 4.5) consists of an operational amplifier, active-admittance filter, and buffer amplifier. A negative feedback trim potentiometer is the vernier gain adjust for the amplifier. Current at the input is converted to voltage at the output. The active-admittance filter is a three pole Bessel filter consisting of a resistor R_1 and an active filter (Y) that attenuates the signal 3dB at the selected cutoff frequency (front panel BANDWIDTH control). Attenuation above the cutoff frequency is 18dB per octave, 60dB per decade. The buffer amplifier is a unity gain amplifier that provides $\pm$100 milliamperes to a load of 100 ohms.

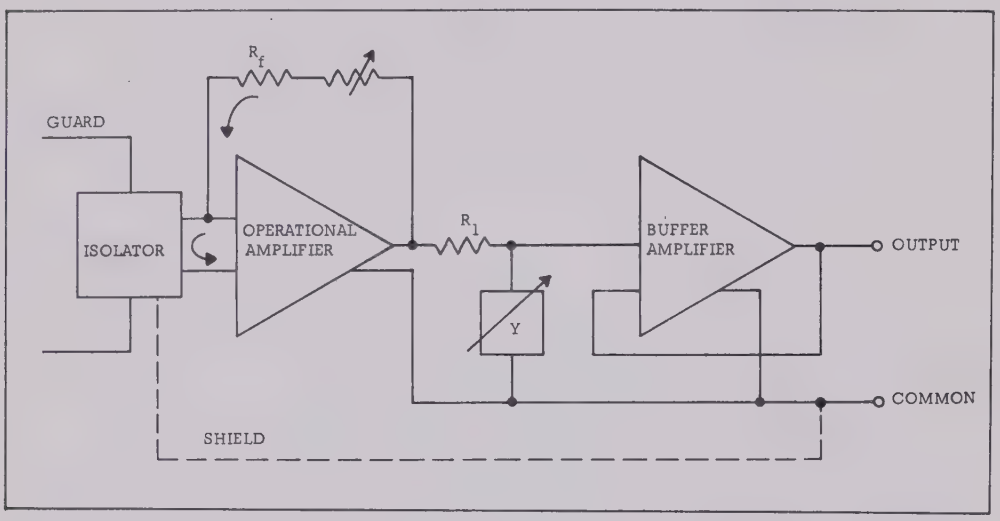


Figure 4.5 - Output Amplifier

SECTION 5

CALIBRATION

5.1 TEST EQUIPMENT

1. OSCILLOSCOPE - X-Y inputs; bandpass, DC - 500 kHz; calibrated deflection factors of 1 millivolt to 20 volts per centimeter accurate within 3%; input impedance, 1 megohm paralleled by less than 50pf.

2. OSCILLATOR - Frequency range, 5 Hz-500kHz; accuracy, ±2%; frequency response, ±1dB; adjustable output voltage, 160 milliwatts (10 volts) into 600 ohms rated load, 20 volts open circuit.

3. VACUUM TUBE VOLTMETER - Voltage range, 0.1 millivolt to 300 volts; dB range, -72 to +52dB; frequency range, 10 Hz to 1 MHz accurate within ±2% (50Hz - 500 kHz); input impedance, 10 megohms paralleled by less than 50pf.

4. ATTENUATOR - Attenuation to 120dB in 1dB steps; DC to 1 MHz accurate within ±dB; power capacity, 5 watts.

5. DC MILLIVOLTMETER (Optional)

6. Dana Adapter Set 2801 (P/N 402468).

5.2 CALIBRATION PROCEDURES

Certain performance characteristics should be checked periodically and internal adjustments made as required. These adjustments are detailed in paragraph 5-4 — Field Calibration.

The Calibration procedure in paragraph 5.5, Major Calibration, should be performed after repair of the instrument.

5.3 FIELD CALIBRATION

Physical location of the adjustable components is shown in Figure 5.1. The procedure below should be performed in the order listed.

NOTE: Common mode potentials appear between the guard box and chassis; therefore, an insulated screwdriver or adjustment tool (J.F.D Adjustment Tool 5284) should be used to make the adjustments.

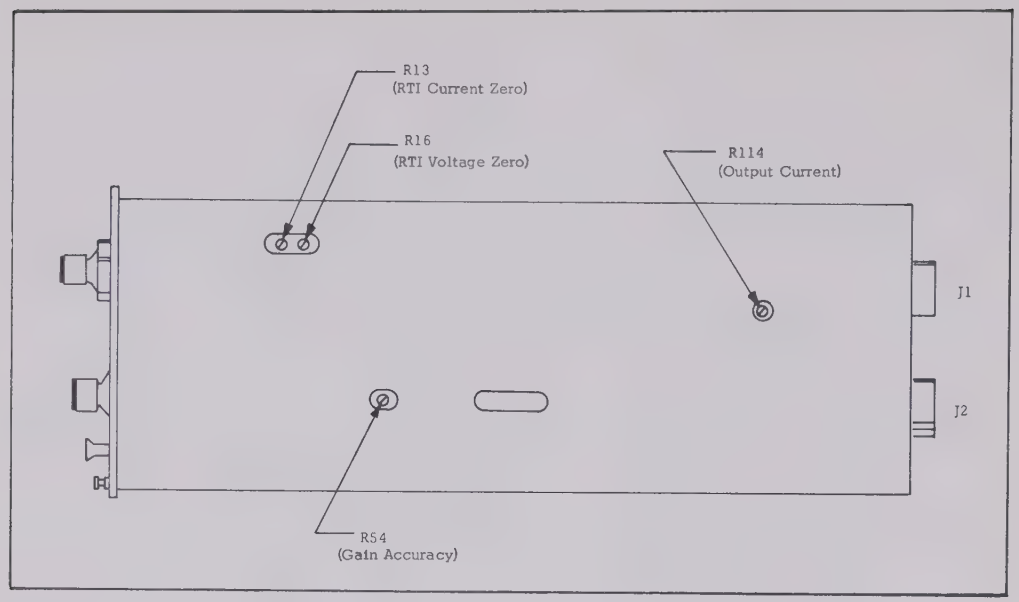


Figure 5.1 - Amplifier Adjustments, Physical Location

5.3.1 Referred to Input (RTI) Voltage Zero

In addition to the operational ZERO adjustment on the front panel, the amplifier is equipped with an internal zero adjustment (R16). Procedure for making the adjustment is as follows:

1. Connect amplifier inputs P(J1-8), N(J1-4), and guard (J1-7) together.

2. Connect an oscilloscope or millivoltmeter to output (J2-5) and common (J2-1).

3. Set the front panel GAIN vernier (R55) fully counterclockwise.

4. Set the GAIN switch to the gain of 1; adjust the front panel ZERO adjustment (R60) for minimum reading on the millivoltmeter. Record any residual offset.

5. Set the amplifier GAIN switch to the gain of 1000; adjust the internal collector zero adjustment (R16) for the same offset recorded in step 4.

6. Repeat steps 4 and 5 until the output remains the same on both the highest and lowest gain settings.

5.3.2 Referred to Input (RTI) Current Zero

This adjustment minimizes current flow through the input terminals. For most accurate adjustment, the following procedure should be performed after the RTI Voltage zero adjustment.

1. Set amplifier GAIN switch to the gain of 1000.

2. Connect input terminals P(J1-8), N(J1-4), and guard (J1-7) together.

3. Set the front panel GAIN vernier (R55) fully counterclockwise.

4. Connect oscilloscope to output (J2-5) and common (J2-1). Set vertical deflection to 1mV/cm. Record amplitude of offset voltage at output.

5. Disconnect P(J1-8) terminal from N(J1-4) and guard (J1-7), insert 1K resistor in series and reconnect to N(J1-4) and guard (J1-7).

6. Adjust R13, the base current zero control, for the same offset recorded in step 4.

5.3.3 Gain Accuracy Adjustment

The gain trim adjustment sets the gain accuracy of the amplifier. The gain accuracy for the V4 option is ±0.1%, the gain accuracy for the V5 option is ±0.01%.

1. Connect the test setup shown in Figure 5.2.

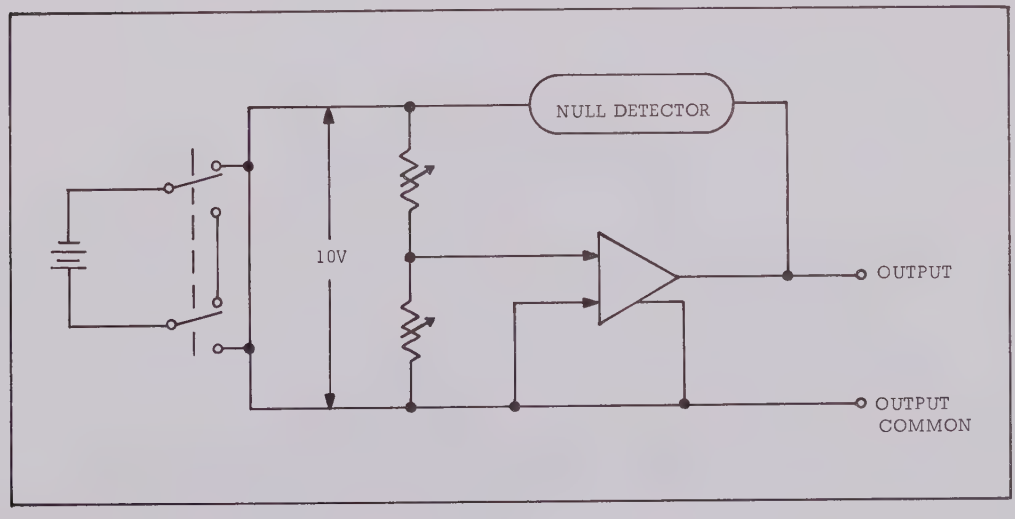


Figure 5.2 - Gain Accuracy Adjustment

2. Set the vernier gain adjustment on the front panel of the amplifier fully counterclockwise.

3. Set the GAIN selector switch of the amplifier to the gain of 100.

4. Set voltage divider* to the reciprocal of gain setting, 1/k. (For the gain of 100, set the voltage divider to 0.01).

5. Adjust the gain trim (R54) for null. For V4 option, adjust for ±10 millivolts; for V5 option, adjust for ±1 millivolt.

5.3.4 Current Limit Adjustment

Potentiometer R114 adjusts the output current. The current should be limited to protect the recording device; however, the current can be limited to 100 milliamperes into a 10 ohm load.

1. Connect a 10 volt power supply, a 10 ohm 1/2 watt load resistor, and a DC voltmeter as shown in Figure 5.3.

2. Adjust R114 until the voltmeter reads 1.0 volts ±10%.

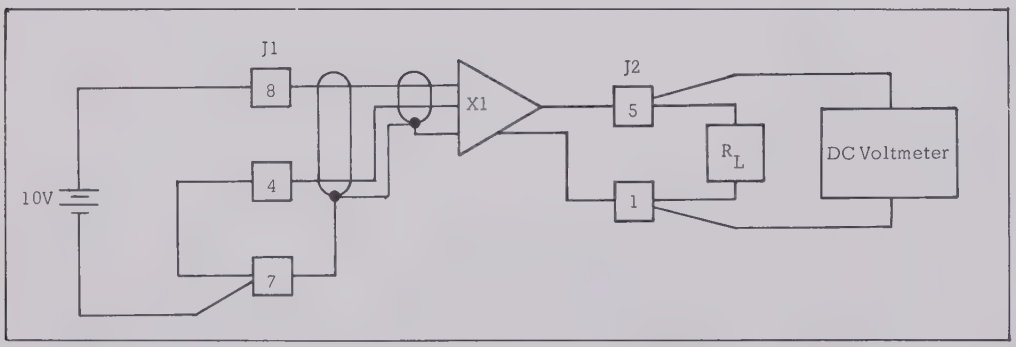


Figure 5.3 - Test Setup, Current Limit Adjust

*The gain accuracy of the amplifier can be no greater than the accuracy of the voltage divider used.

5.4 MAJOR CALIBRATION

Disassemble the amplifier per paragraph 5.5.

5.4.1 Output Amplifier Zero Adjustment

Potentiometer R67 (reference assembly drawing 402473) adjusts the zero of the output amplifier.

1. Apply power to the amplifier and allow 30 minutes for warm-up.
2. Connect terminal E60 (reference assembly drawing 402473) to output common (pin 1 of connector J2).
3. Connect an oscilloscope or millivoltmeter to output (pin 5 of connector J2) and output common (pin 1 of connector J2).
4. Set the front panel GAIN vernier (R55) full counterclockwise.
5. Adjust potentiometer R67 (reference assembly drawing 402473) for ±5 volts.
6. Remove the common connection from terminal E60; connect terminal E61 to common.
7. Adjust potentiometer R52 (reference assembly drawing 402473) for zero volts ±200 microvolts.
8. Remove the common connection to terminal E61.

5.4.2 Referenced to Output (RTO) Zero Adjustment

1. Connect the P(J1-8), N(J1-4), and guard (J1-7) leads together.
2. Place the GAIN switch to the gain of 1.
3. Connect a millivoltmeter to output (J2-5) and output common (J2-1).
4. Set the front panel GAIN vernier (R55) fully counterclockwise.
5. Set the front panel ZERO (R60) for zero volts ±500 microvolts; record this voltage for further reference.
6. Set the front panel GAIN vernier (R55) fully clockwise; adjust potentiometer R52 (reference assembly drawing 402473) for the same value recorded in step 5.

7. Set the front panel GAIN vernier (R55) fully counterclockwise. The offset voltage should be the same as the voltage recorded in step 5.

8. Repeat steps 4 through 7 until the offset voltage remains the same.

5.4.3 Referred to Input (RTI) Voltage Zero Adjustments

Perform the calibration procedure in paragraph 5.3.1.

5.4.4 Referred to Input (RTI) Current Zero Adjustment

Perform the calibration procedure in paragraph 5.3.2.

5.4.5 Gain Accuracy Adjustment

Perform the calibration procedure in paragraph 5.3.3.

5.4.6 Current Limit Adjustment

Perform the calibration procedure in paragraph 5.3.4.

5.5 AMPLIFIER DISASSEMBLY

Remove eight, number 6, Phillips flat-head screws from the aluminum support (right-hand side of the amplifier as viewed from the front panel.)

To remove the cover, place the amplifier in the left hand and pull the cover toward the rear of the amplifier as shown in Figure 5.4a.

To remove the aluminum support, remove six, number 4, Phillips pan-head screws holding the circuit board assembly to the aluminum support. Three screws are at the top of the circuit board assembly; the other three screws are at the bottom of the circuit board assembly. Place the amplifier in the left hand and push the circuit board assembly as shown in Figure 5.4b.

Figure 5.4a

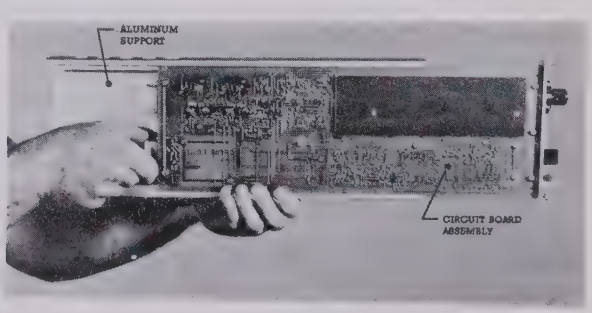


Figure 5.4b

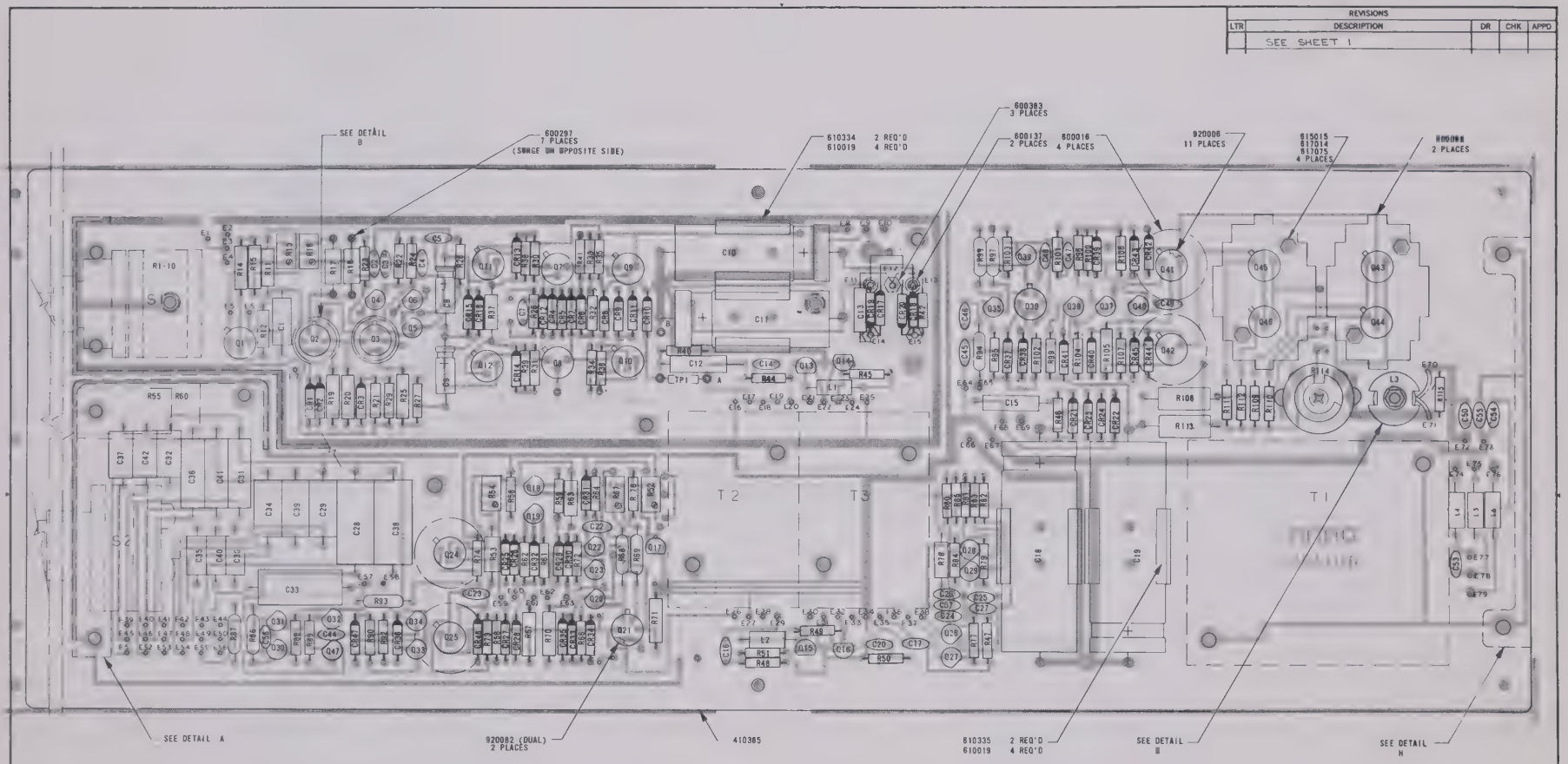
SECTION 6

DRAWINGS AND PARTS LISTS

6.1 DRAWINGS

PCB Assembly - Model 2860	402473
Schematic - Model 2860	430654
Dimensional Outline - Model 2860	452648
Dimensional Outline - Enclosure Model 2808-1	452402
Dimensional Outline - Enclosure Model 2808-2	452403

REVISIONS				
LTR	DESCRIPTION	DR	CHK	APPD
	SEE SHEET 1			



(SEE SHEET 3 FOR NOTES)

NOTE: UNLESS OTHERWISE SPECIFIED

QTY REQD	DANA PART NUMBER	NOMENCLATURE OR DESCRIPTION	CODE IDENT	SPECIFICATION OR VENDOR P/N	ITEM NO.
		LIST OF MATERIAL OR PARTS LIST			

402474	2860	1	1
NEXT ASSY	USED ON	NA	FA
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON: DECIMALS | ANGLES | FORMED ANGLES
X .030 | 0° 30' | 1.0
.XX .020
.XXX .010

MATERIAL

FINISH

CONTRACT NO.

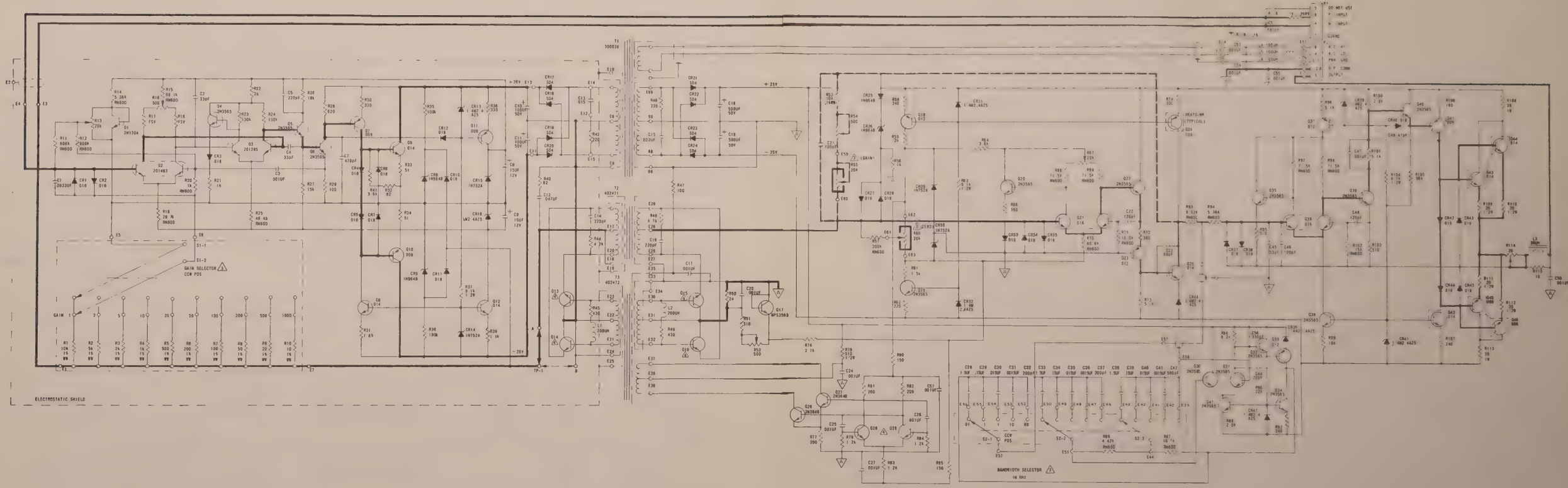
DRAWN J. M. Richards 9/7/67
CHECK
DESIGN R. Bailey 9/6/67
PROJ ENGR
Clement 10/6/67

DANA LABORATORIES INC.
IRVINE, CALIFORNIA

P C BOARD ASSY
POST ISOLATOR

SIZE	CODE IDENT NO	DWG NO.	REV
D	21793	402473	

SCALE 2/1 WT SHEET 2 OF 8



QTY REQD	DANA PART NUMBER	NOMENCLATURE OR DESCRIPTION	CODE IDENT	SPECIFICATION OR VENDOR P/N	ITEM NO

LIST OF MATERIAL OR PARTS LIST

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON DECIMALS: ANGLES: FORMED ANGLES

MATERIAL

FINISH

CONTRACT NO

DRAWN

CHECK

DESIGN

PROJ ENGR

APPD

DANA LABORATORIES INC.
IRVINE, CALIFORNIA

SCHEMATIC,
POST ISOLATOR

SIZE	CODE IDENT NO	DWG NO	REV
D	17-1	430654	

SCALE NONE WT SHEET 2 OF 2

REF DES	PART NO.	DESCRIPTION
C34	120130	.15UF
C33	120128	1.5UF
C32	130056	200pF
C31	130051	.0015UF
C30	120131	.015UFX
C29	120130	.15UF
C28	120128	1.5UF
C27	101174	.001UF
C26	101174	.001UF
C25	101174	.001UF
C24	101174	.001UF
C23	100010	68pF
C22	100018	120pF
C21	101145	180pF
C20	101174	.001UF
C19	110062	500UF
C18	110062	500UF
C17	101174	.001UF
C16	101175	220pF
C15	121468	.022UF
C14	101175	220pF
C13	120131	.015UF
C12	121093	.047UF
C11	110061	100UF
C10	110081	100UF
C9	110064	15UF
C8	110064	15UF
C7	101841	470pF
3		
C5	101175	220pF
C4	100012	33pF
C3	101174	.001UF
C2	100012	33pF
C1	120001	.0033UF

REF DES	PART NO.	DESCRIPTION
CR8	220016	1N964B
CR7	211083	018
CR6	211083	018
CR5	211083	018
CR4	211083	018
CR3	211083	018
CR2	211083	018
CR1	211083	018
C57	101174	.001UF
C56	101098	330pF
C55	101174	.001UF
C54	101174	.001UF
C53	101174	.001UF
3		
C51	101099	680pF
C50	101174	.001UF
C49	101182	47pF
C48	100018	120pF
C47	101174	.001UF
C46	101145	100pF
C45	100012	33pF
C44	100005	22pF
4		
C42	130057	560pF
C41	130051	.0015UF
C40	120131	.015UFX
C39	120130	.15UF
C38	120128	1.5UF
C37	130056	200pF
C36	130051	.0015UF
C35	120131	.015UFX

REF DES	PART NO.	DESCRIPTION
CR42	211083	018
CR41	220030	1/4M2.4AZ5
CR40	211083	018
CR39	220030	1/4M2.4AZ5
CR38	211083	018
CR37	211083	018
CR36	220030	1/4M2.4AZ5
CR35	211083	018
CR34	211083	018
CR33	211083	018
CR32	220030	1/4M2.4AZ5
CR31	220030	1/4M2.4AZ5
CR30	220019	IN752A
CR29	220019	IN752A
CR28	211083	018
CR27	211083	018
CR26	220016	IN964B
CR25	220016	IN964B
CR24	210004	SD4
CR23	210004	SD4
CR22	210004	SD4
CR21	210004	SD4
CR20	210004	SD4
CR19	210004	SD4
CR18	210004	SD4
CR17	210004	SD4
CR16	220030	1/4M2.4AZ5
CR15	220019	IN752A
CR14	220019	IN752A
CR13	220030	1/4M2.4AZ5
CR12	211083	018
CR11	211083	018
CR10	211083	018
CR9	220016	IN964B

REF DES	PART NO.	DESCRIPTION
Q17	200071	MPS3563
Q16	200072	(MATCHED PAIR)
Q15	200072	(MATCHED PAIR)
Q14	200072	(MATCHED PAIR)
Q13	200072	(MATCHED PAIR)
Q12	200035	014
Q11	200011	009
Q10	200011	009
Q9	200035	014
Q8	200035	014
Q7	200011	009
Q6	200043	2N3565
Q5	200043	2N3565
Q4	200043	2N3565
Q3	201285	2ND STG DUAL
Q2	201463	1ST STG. DUAL
Q1	201084	2N1304
L6	310033	100UH
L5	310033	100UH
L4	310033	100UH
L3	402470	30 UH
L2	310034	200UH
L1	310034	200UH
CR47	220030	1/4M2 4AZ5
CR46	220030	1/4M2 4AZ5
CR45	211083	018
CR44	211083	018
CR43	211088	018

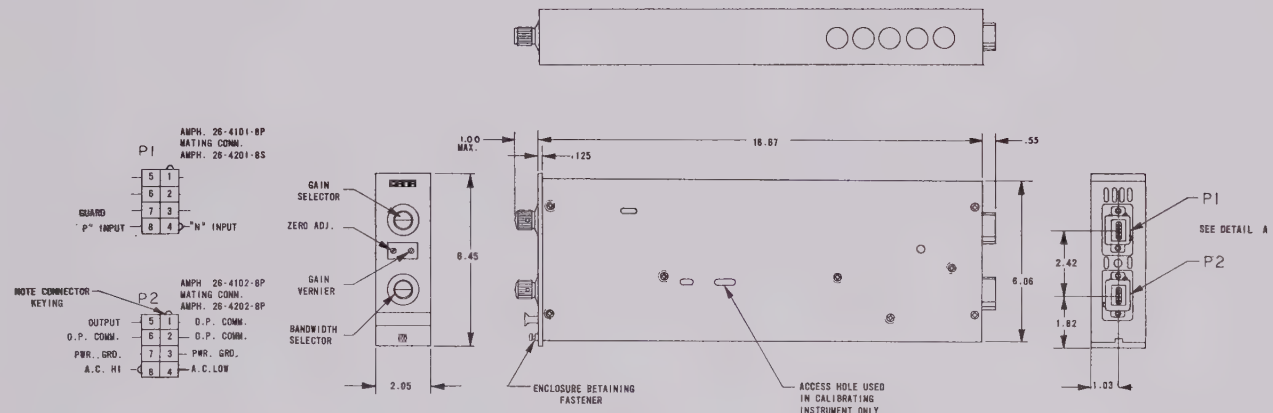
REF DES	PART NO.	DESCRIPTION
R1	020388	10k .1%WW
Q47	200043	2N3565
Q46	200011	009
Q45	200011	009
Q44	200035	014
Q43	200035	014
Q42	200035	014
Q41	200011	009
Q40	200043	2N3565
Q39	200043	2N3565
Q38	200043	2N3565
Q37	200022	012
Q36	200040	016
Q35	200043	2N3565
Q34	200043	2N3565
Q33	200022	012
Q32	200043	2N3565
Q31	200043	2N3565
Q30	200043	2N3565
Q29	200074	(MATCHED PAIR)
Q28	200074	(MATCHED PAIR)
Q27	200037	2N3646
Q26	200037	2N3646
Q25	200035	014
Q24	200011	009
Q23	200022	012
Q22	200043	2N3565
Q21	200040	016
Q20	200043	2N3565
Q19	200043	2N3565
Q18	200022	012

REF DES	PART NO	DESCRIPTION
R35	000104	100k
R34	000510	51
R33	000510	51
R32	000820	82
R31	000182	1.8k
R30	000331	330
R29	000101	100
R28	000621	620
R27	000153	15k
R26	000183	18k
R25	010022	46.4k RN60D
R24	000134	130k
R23	000134	130k
R22	000302	3k
R21	000102	1k
R20	010259	1k RN60D
R19	010122	28.7k RN60D
R18	400087	FSV
R17	400087	FSV
R16	040093	500 POT
R15	010120	68.1k RN60D
R14	010112	5.36k RN60D
R13	040092	20k POT
R12	010336	806k RN60D
R11	010336	806k RN60D
R10	020382	10 .1%WW
R9	020383	20 1%WW
R8	020335	50 1%WW
R7	020384	100 1%
R6	020202	200 1%WW
R5	020240	500 1%WW
R4	020139	1k 1%WW
R3	020385	2k .1%WW
R2	020141	5k .1%WW

REF DES	PART NO	DESCRIPTION
R89	010075	71.5k RN60D
R88	010075	71.5k RN60D
R87	040092	20k POT
R86	000361	360
3		
R84	000362	3.8k
R83	001102	9.1k 1/2W
R82	000221	220
R81	000152	1.5k
R80	040040	20k POT
R59	000202	2k
R58	000241	240
R57	010158	200k
R56	000102	1k
R55	040103	20k POT
R54	040093	500 POT
R53	020386	10k 1%WW
R52	040093	500 POT
R51	000511	510
R50	000240	24
R49	000431	430
R48	000472	4.7k
R47	000101	100
R46	000221	220
R45	000431	430
R44	000472	4.7k
3		
R42	000221	220
R41	000362	3.6k
R40	000820	82
R39	000112	1.1k
R38	000331	330
R37	001102	9.1k 1/2W
R36	000104	100k

REF DES	PART NO	DESCRIPTION
R103	000511	510
R102	010113	15k RN60D
R101	000512	5.1k
R100	000202	2k
R99	000183	18k
R98	010075	71.5k RN60D
R97	010075	71.5k RN60D
R96	000512	5.1k
R95	000511	510
R94	010112	5.36k RN60D
R93	010086	9.53k RN60D
R92	000241	240
3		
R90	000223	22k
R89	000202	2k
R88	000822	8.2k
R87	010324	10.7k RN60D
R86	010211	4.42k RN60D
R85	000151	150
R84	000122	1.2k
R83	000122	1.2k
R82	000201	200
R81	000201	200
R80	000151	150
R79	000122	1.2k
R78	001706	510, 1/2W
R77	000201	200
R76	000272	2.7k
3		
R74	000301	300
R73	000512	5.1k
R72	000361	360
R71	010080	10.0k RN60D
R70	010077	80.6k RN60D

REF DES	PART NO	DESCRIPTION
T3	402472	DRIVE XMFR
T2	402471	ISOLATOR XMFR
T1	300039	POWER XMFR



DETAIL 'A'

WIRING TYPICAL OF DANA CORD SET NO.402468 AND DANA MODEL 2808-1 AND 2808 2 ENCLOSURE

NOTE: UNLESS OTHERWISE SPECIFIED

QTY REQD	DANA PART NUMBER	NOMENCLATURE OR DESCRIPTION	CODE IDENT	SPECIFICATION OR VENDOR P/N	ITEM NO.
		LIST OF MATERIAL OR PARTS LIST			

402474	2860		
NEXT ASSY	USED ON	NA	FA
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON:
DECIMALS | ANGLES 0° 30' | FORMED ANGLES ±0
.XX ±.03
.XXX ±.010

MATERIAL

FINISH

CONTRACT NO.

DANA LABORATORIES INC.
IRVINE, CALIFORNIA

DRAWN	[illegible]	8/5/67
CHECK		
DESIGN	J. F. Sellers	8/11/67
PROJ ENGR	J. Boyce	8/4/67
	Request	10/1/67

OUTLINE DIMENSIONAL-AMPLIFIER MODEL 2860

SIZE	CODE IDENT NO	DWG NO.	REV
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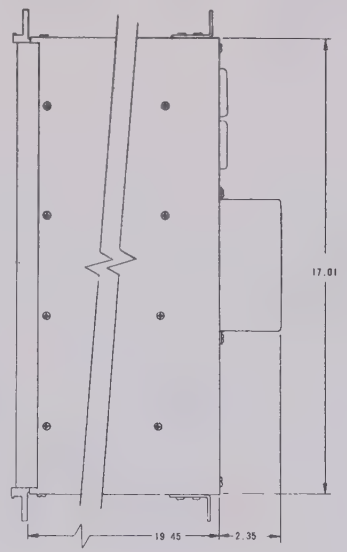
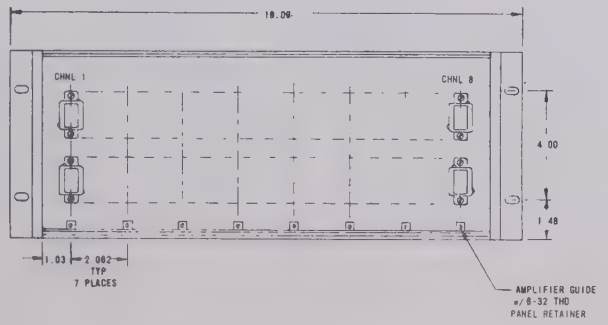
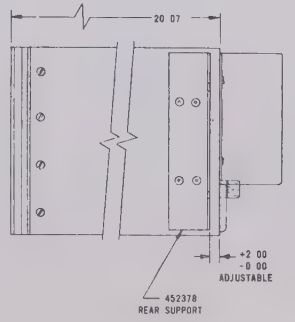
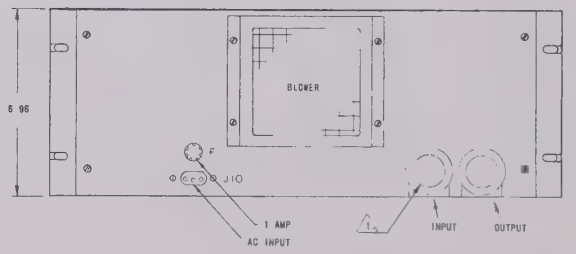
SCALE 1/2	WT	SHEET 1 OF 1	









⚠1 ENCLOSURE WIRING PER DANA DRAWING # 430590

NOTE: UNLESS OTHERWISE SPECIFIED

QTY REQD	DANA PART NUMBER	NOMENCLATURE OR DESCRIPTION	CODE IDENT	SPECIFICATION OR VENDOR P/N	ITEM NO.
		LIST OF MATERIAL OR PARTS LIST			

452398	2808-1	REF	REF	
NEXT ASSY	USED ON	NA	FA	
APPLICATION		QTY REQD		

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON:
DECIMALS ANGLES
X .030 0° 30'
.XX .010
.XXX .010
FORMED ANGLES 1.0

MATERIAL

FINISH

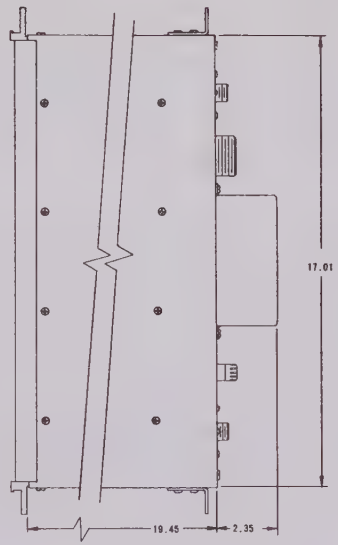
CONTRACT NO.

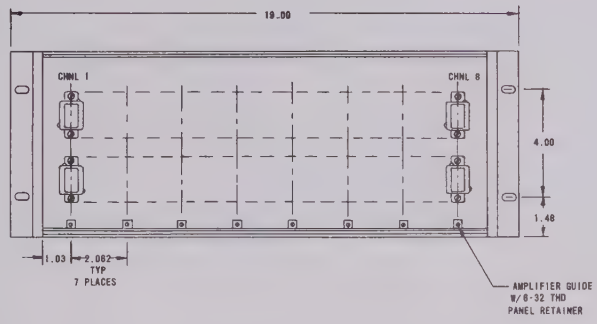
DANA LABORATORIES INC.
IRVINE, CALIFORNIA

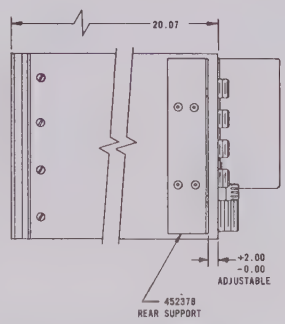
DRAWN	G WILSON	6/22/67
CHECK		
COG ENGR		
PROJ ENGR		

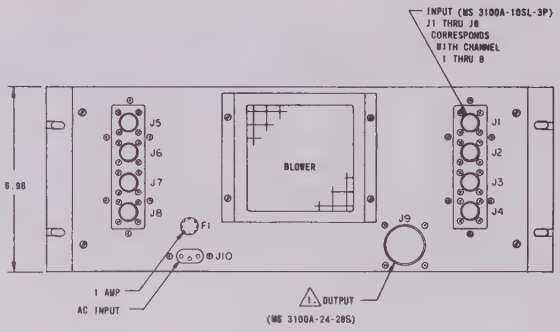
OUTLINE DIMENSIONAL
ENCLOSURE
MODEL 2808-1

SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	452402	
SCALE	WT	SHEET 1 OF 1	









QTY REQD	DANA PART NUMBER	NOMENCLATURE OR DESCRIPTION	CODE IDENT	SPECIFICATION OR VENDOR P/N	ITEM NO.
		LIST OF MATERIAL OR PARTS LIST			

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON: DECIMALS X .030 XX .010 XXX .010 | ANGLES 0° 30' | FORMED ANGLES 1.0

MATERIAL

FINISH

CONTRACT NO.

DANA LABORATORIES INC.
IRVINE, CALIFORNIA

DRAWN	G WILSON	6/22/67
CHECK	W.S. Selberg	27 JUNE 67
COG. ENGR.	[illegible]	6-27-67
PROJ. ENGR.	[illegible]	6/29/67

OUTLINE DIMENSIONAL
ENCLOSURE
MODEL 2808-2

SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	452403	

SCALE 1/2 WT SHEET 1 OF 1

402371	2808-2	REF	REF
NEXT ASSY	USED ON	NA	FA
APPLICATION		QTY REQD	

⚠1 ENCLOSURE WIRING PER DANA DRAWING # 430581.

NOTE: UNLESS OTHERWISE SPECIFIED

Warranty

It is the practice of Dana Laboratories, Incorporated, to manufacture only products of a quality that will merit customer satisfaction. The company recognizes that customer satisfaction is achieved, not only by delivering products meeting advertised performance specifications and having a high level of reliability, but also by honestly and efficiently fulfilling their warranty obligations as set forth below.

Dana Laboratories, Inc., agrees to correct, either by repair or replacement, any defect of material or workmanship in Dana-manufactured units or components which develop within one year after delivery of the equipment to the original purchaser — provided that the equipment has been subjected only to normal and proper use.

In the event of failure of any component delivered with Dana equipment, but not manufactured by Dana Laboratories, assistance will be given the customer in obtaining, from the original manufacturer, reasonable adjustment under that manufacturer's warranty.

Any item claimed to be defective during the warranty period must be returned to Dana Laboratories, Inc., with transportation charges prepaid. The item will be repaired and returned to the purchaser with return transportation prepaid by Dana unless, of course, the item is found not to be defective or found to be damaged by misuse — in which case it will be returned to the purchaser with repair and transportation billed collect.

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